Notes on the longevity, fecundity and development of *Pissodes terminalis* Hopping (Coleoptera: Curculionidae) in the Interior of British Columbia, Canada

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ABSTRACT

The biology and life history of the lodgepole terminal weevil, *Pissodes terminalis,* was studied in the interior of British Columbia, Canada. Average longevity of females of *P. terminalis was 112.8 days at 20*°C. Mean lifetime fecundity was 115 eggs per female. The egg stage lasted 8 days, and pupation took 15 days. In the field, egg laying started at the beginning of June and all larvae reached the final instar by early September. Pupation began in mid-September and at the end of the month the first adult was ready to emerge.

INTRODUCTION

Large areas of mature lodgepole pine (*Pinus contorta* Doug. ex Loud) in the Interior of British Columbia have been infested during the last two decades by the mountain pine beetle, *Dendroctonus ponderosae* Hopk. These have been managed by salvage logging the infested forests and now there are large areas of young lodgepole pine forests. Such stands are vulnerable to attack by regeneration pests (Amman and Safranyik 1984) one of the most important of which is the lodgepole terminal weevil, *Pissodes terminalis* Hopping.

Adults typically emerge from the leaders in early summer and after some maturation feeding, the females lay eggs into the elongating terminal shoot of host trees. Newly hatched larvae mine just beneath the epidermis; later instars burrow into the pith and mine towards the apical bud. Pupation occurs in the pith. Most of the weevils overwinter as late instar larvae but pupae and adults may also overwinter in the terminal.

Larval feeding in the phloem-cambium region and in the pith results in the death of the terminal. Dead terminals are replaced by laterals, resulting in the formation of crooks, forks in the main stem, and in severe cases, in multi-leadered crowns (Stevenson and Petty 1968; Stevens and Knopf 1974; Duncan 1986). Beside deformities, the trees also suffer height growth loss (Maher 1982; Amman and Safranyik 1984).

Leader clipping trials for the lodgepole terminal weevil (MoF 1984), as an experimental control method, have been carried out to reduce weevil numbers. Knowledge of the biology and life history of the weevil can play an important role in the timing of leader clipping operations. Although the impact of *P. terminalis* on young lodgepole pine trees has been studied in the past (Maher 1982), no detailed information is available on this pest's biology in British Columbia. Our objectives were to investigate: the longevity and fecundity of adult female *P. terminalis;* the duration of egg and pupal stages; the development of the weevil from egg to adult in field conditions.

METHODS AND MATERIALS

Longevity and fecundity.

Ten pairs of *P. terminalis* adults were placed in 0.5 L jars covered with cheese cloth and kept at room temperature, 20 ± 2°C. Each day a 10-cm-long section of lodgepole pine terminal was placed in each jar from a supply of cut leaders that was kept refrigerated. Numbers of feeding punctures, oviposition sites and numbers of eggs per oviposition site were counted daily using a dissecting microscope.

Table 1
Longevity and ovipositional characteristics of ten female *Pissodes terminalis* reared at 20 ± 2°C.

Characteristics	Mean	+ S.D.	Range
Longevity (days)	112.8	74.9	32–226
Preoviposition period (days)	10.1	6.8	2–22
Total eggs/female	115.0	67.5	9–216
Eggs/oviposition site	0.94	*	0–2
Eggs/female/day**	1.57	1.34	0.39–4.62

* S.D. not calculated
** From first to last day of oviposition

Duration of the egg stage.
Sections of the current year's terminal growth with oviposition sites, obtained from the longevity and fecundity experiment, were placed on moist paper towels in closed paper boxes maintained at room temperature. Desiccation of the leaders was prevented by moistening the paper towels daily. The eggs were checked daily and hatching recorded. After each daily examination the oviposition sites were closed to prevent desiccation of the eggs.

Duration of the pupal period.
Twenty weevil larvae were obtained from dissections of one-year-old infested lodgepole pine leaders. Each larva was kept in a 3–4 cm long section of the leader which was placed in a separate petri dish at 20 ± 2°C. Dates of pupation and adult emergence were recorded for each larva.

Development of *P. terminalis* in the field.
Weekly collections at Ellis Creek, 25 km east of Penticton, B.C., were made between June 5, 1987 and September 30, 1987. Ten attacked leaders were clipped with a hand pruner and taken back to the laboratory where they were dissected. Numbers of all weevil developmental stages were recorded. To relate the weevil's life history with leader phenology, 25 lodgepole pine trees with unattacked terminals were randomly chosen and marked with red plastic ribbon. A number was assigned to each tree so that repeated measurements could be taken from the same tree. Elongation of the leaders was measured and recorded every 7 days.

RESULTS AND DISCUSSION

Longevity and fecundity.
Average longevity of the 10 female *P. terminalis* was 112.8 days after emergence from the puparia; one female lived for 226 days (Table 1). Fontaine and Foltz (1985) found that longevity of adult female deodar weevils, *Pissodes nemorensis* Germar, was 130.5 days (S.D. = ± 63.3; range = 1–198) under laboratory conditions of 25 ± 1°C. McMullen and Condrashoff (1973) reported that adults of *Pissodes strobi* (Peck) can live up to 4 years in the field.

We observed that female *P. terminalis* are able to lay eggs as early as 2 days following emergence and therefore they do not require a long maturation feeding. The preoviposition period averaged 10.1 days (Table 1). In contrast, the corresponding time for *P. nemorensis* was 36.6 days (S.D. = 6.1; range = 28–47) at 25 ± 1°C (Fontaine and Foltz 1985).

The first eggs were laid on the second day, after which oviposition increased until day 21 (Fig. 1). There was a sharp decline in the number of eggs laid between day 21 and day 28, but there was a resurgence of oviposition in the following 7 day period. A very similar pattern was observed by Fontaine and Foltz (1985): after a period of increasing oviposition by *P. nemorensis,* the number of eggs laid suddenly "declined to about one-half its peak value on day 90, and then increased again until day 130." They assumed that

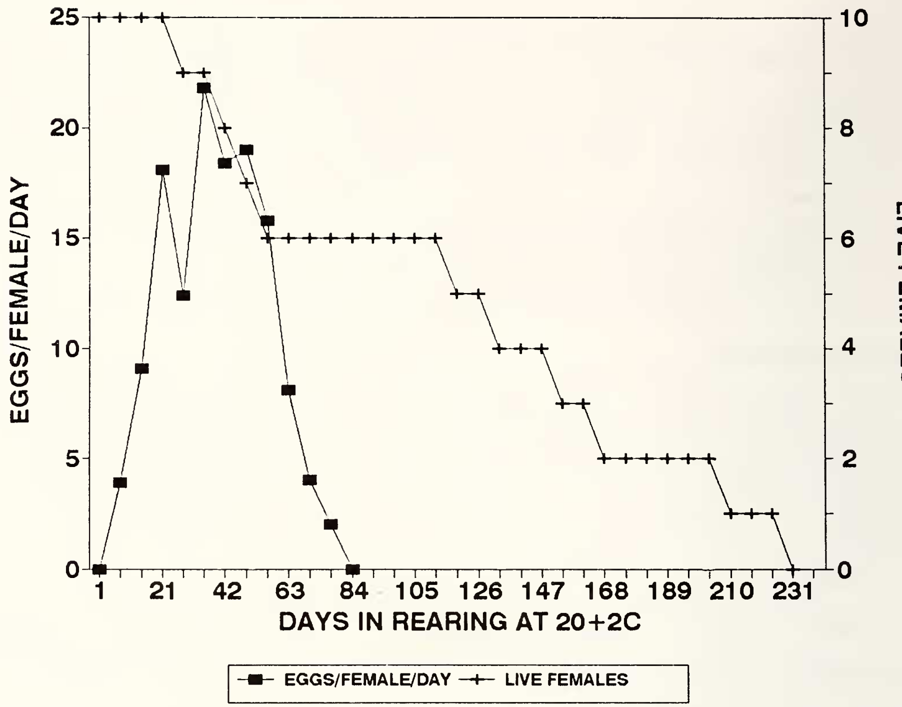

Fig. 1. Survival and fecundity of ten caged *Pissodes terminalis* females at 20 ± 2°C.

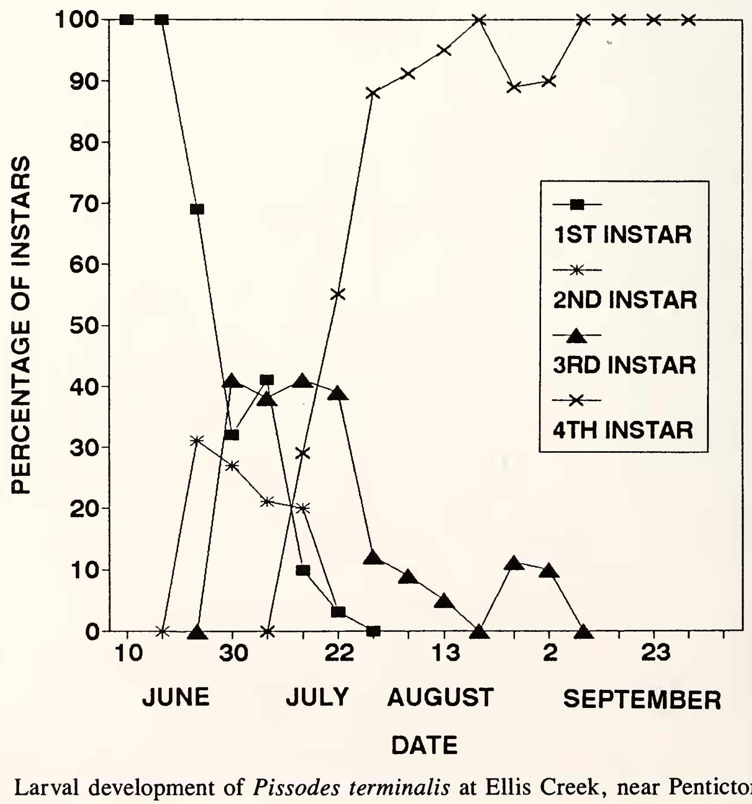

Fig. 2. Larval development of *Pissodes terminalis* at Ellis Creek, near Penticton, B.C. in the summer of 1987.

changing host quality caused the decline. Oviposition by *P. terminalis* reached its peak on day 35 and declined sharply afterwards, although more than half of the females were still alive. The last egg was laid on day 80.

The mean fecundity was 115 eggs per female, although one female laid 216 eggs (Table 1). Total numbers of eggs laid by *P. strobi* (Graham 1926) and *P. nemorensis* (Fontaine and Foltz 1985) averaged 115 and 284, respectively.

From the weekly field collections, a total of 1246 oviposition sites were counted and 1150 eggs were found, a mean of 0.94 eggs per oviposition site. This result is slightly smaller than the reported 1.19 eggs per site for *P. nemorensis* (Fontaine and Foltz 1985), and 1.4 eggs per site for *P. strobi* on Sitka spruce, *Picea sitchensis.* (Gara et al. 1971). Females of *P. terminalis* most often laid one egg per pit (91.6%), but sometimes they oviposited two eggs (0.5%) or none (7.5%). Sealed but empty oviposition pits were most often found towards the end of the oviposition period. Five eggs were laid directly on the bark surface (0.4%). These results support previous findings that generally only one egg is deposited in each pit (Drouin *et al.* 1963; Stark and Wood 1964). Females laid an average of 1.57 eggs per day.

Duration of the egg stage.

Observation of 54 eggs of *P. terminalis* revealed that the average duration of the egg stage was 8 days (S.D. = ±0.98; range = 5–18). This is in agreement with the findings of Stevens and Knopf (1974) who reported that eggs of *P. terminalis* hatch within 2 weeks. We observed that two eggs hatched 5 days after oviposition and 9 took 18 days to hatch.

Duration of the pupal period.

Observations of 20 *P. terminalis* pupae showed that on an average it took 15 days (S.D. = ±2.5; range = 11–20) from pupation to adult emergence at 20°C.

Observations of the development in the field.

The first adult *P. terminalis* was observed on a one-year-old attack on May 10, 1987. Neither an emergence hole nor fresh feeding punctures were observed on the terminal. Six more adults were observed on elongating leaders within the next ten days. The observations suggest that these weevils may have emerged in the previous fall and overwintered probably in the duff.

Daily examination of 50 dead leaders, attacked in 1986 revealed the first weevil emergence hole on June 19, 1987. However, the first current year's attack was recorded on June 3, 1987 suggesting that these eggs may have been laid by overwintering adults. The last eggs were observed on July 22, 1987.

Figure 2 shows the development of *P. terminalis* in the field at Ellis Creek, near Penticton, B.C. Prolonged egg laying by emerging adults and egg hatching resulted in first-instar larvae being present from the beginning of June through July 22, 1987. This is the date when the last second-instar larvae were recorded. In 1961, Stark and Wood (1964) found that in central Sierra Nevada, California, first- and second-instar larvae of *P. terminalis* were present until the end of July. In the present study, third-instar larvae were observed in the pith from the end of June through the beginning of September, 1987 (Fig. 2). Last-instar larvae were found on July 14, 1987 and by the end of the month they were commonly encountered. Ninety-five percent of the larvae were in the pith on Aug. 13, 1987. By September 9, 1987 all larvae reached the final instar. Stark and Wood (1964) reported that all larvae were in the last instar on September 6, 1961.

The first pupa was recorded on September 17, 1987 and two weeks later the first adult was ready to emerge. These observations suggest that, in this locality, *P. terminalis* overwinters as a fourth instar rather than a third instar larva. Pupae and adults also overwinter inside the terminal. Emerged weevils probably hibernate in the duff (Furniss and Carolin 1977).

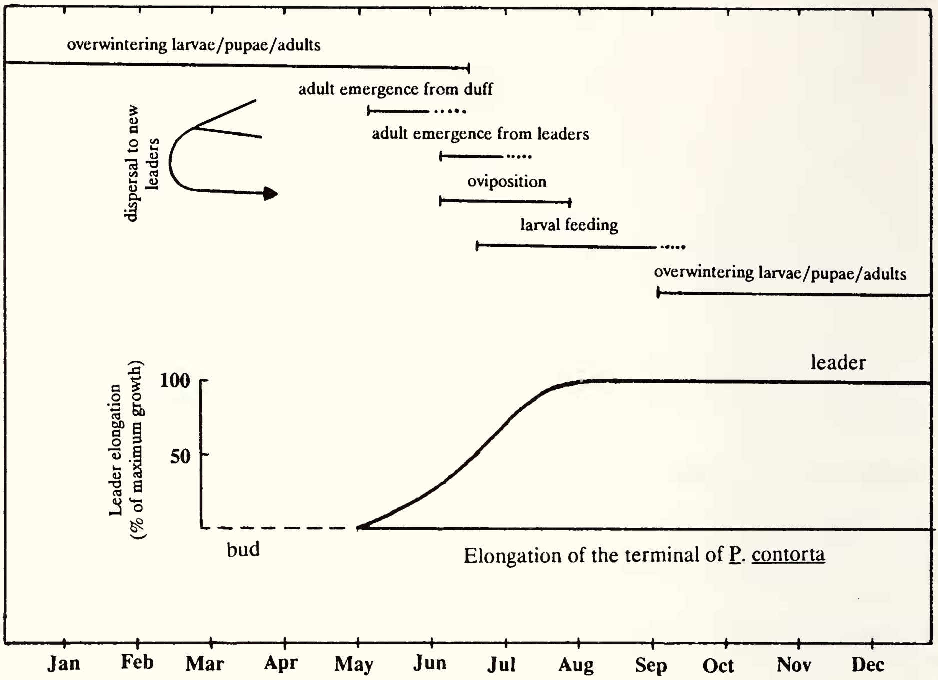

Fig. 3. Life cycle of *Pissodes terminalis* at Ellis Creek, near Penticton, B.C. in the summer of 1987.

On average, 3.4 larvae per tip (S.D. = ±2.79; range = 1–17; n = 160) were found. This number is slightly smaller than the 4.2 larvae per tip (range = 1–19; n = 305) found by Stark and Wood (1964) in California. Since adult females oviposit into the elongating terminal the coincidence of the greatest leader growth and ovipositional period is critical for successful oviposition. Figure 3 shows the relationship between oviposition and tip elongation at Ellis Creek in 1987. Leader growth started at the beginning of May and it was practically finished by the end of July. Only slight height growth was recorded in the first 2 weeks of August. Oviposition was restricted to the second half of the elongation period. Figure 3 also summarizes field observations on the life cycle of the lodgepole terminal weevil at Ellis Creek. Late-instar larvae, pupae and adults overwinter. Adult weevils start emerging in early May and egg laying begins early June. By mid-September all larvae reach the final instar and the first pupae are encountered in late September when some of the adults emerge. The life cycle of *P. terminalis* follows type 1, 2A, 2B and 2C life cycles described by Cameron and Stark (1989) from the Sierra Nevada.

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Note on the occurrence of *Paravespula germanica* (Hymenoptera: Vespidae) in the Lower Fraser Valley of British Columbia

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The German yellowjacket, *Paravespula germanica* (Fab.), was not known to occur in the Pacific Northwest prior to 1981. The first collections of this wasp were made in 1981 in Nampa, Idaho, and in 1982 in Puyallup, Washington (MacDonald and Akre, 1984). Buckell and Spencer (1950) did not include *P. germanica* in their list of vespid wasps of British Columbia. Akre *et al.* (1989) gave the range of this species in North America.

In the summers of 1984 and 1985, I netted yellowjacket workers in Cloverdale, B.C. and keyed them to *P. germanica* using the key in Akre *et al.* (1980). These wasps were sent to Akre, who confirmed their identity and retained them in the collection of the Washington State University, Pullman.